Development of an Ear Print Enhancer from Coconut Shell Charcoal

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***Abstract*—In this research, an environmentally friendly ear print enhancer made from coconut shell charcoal is developed and evaluated. Conventional forensic powders are frequently hazardous to the environment and human health because of their chemical makeup, which includes nanoparticles like titanium dioxide (TiO_2), and they are not very good at capturing more diffuse, less distinct biological imprints like ear prints. On the other hand, the powdered biogenic charcoal generated in this study provides a non-toxic, sustainable, and natural substitute. The coconut shells were pulverized into a fine powder and carbonized before being placed on clean, nonporous surfaces like glass to create latent ear prints. The powder enhanced anatomical features such as the helix, antihelix, tragus, and lobule by exhibiting exceptional adherence to perspiration and sebum residues. The visibility of earlobe piercings, which may help with gender identification, was a significant discovery. The generated ear prints were durable with little smearing and had excellent contrast and clarity. The coconut charcoal mixture provided competitive performance without sacrificing user safety when compared to commercial powders. In order to improve practical forensic applications, the study emphasizes the potential of materials obtained from agro-waste and suggests additional standardization and surface adaptability testing.**

***Index Terms*—Ear Print Visualization, Coconut Shell Charcoal, Forensic Science, Biogenic Powder, and Eco-Friendly Latent Print Development.**

I. INTRODUCTION

1.1 OVERVIEW OF LATENT PRINT DEVELOPMENT IN FORENSIC SCIENCE

Latent prints, which are made up of perspiration, sebum, and skin oils, are undetectable until they are carefully enhanced with chemicals or powders. Using tiny hydrophobic particles that adhere to greasy residues, the conventional powder dusting method reveals complex ridge patterns [1]. Alternatives made from agronomic waste, such as carbon powders derived from coconut shells or husks, have garnered interest lately. research done showed that, using automated minutiae scoring (up to 60 points), coconut husk carbon powder (particle size ~20 µm) can create latent fingerprints on nonporous and semiporous surfaces with effectiveness comparable to commercial powders. These results highlight environmentally friendly methods for forensic improvement [2].

1.2 SIGNIFICANCE OF EAR PRINTS AS BIOMETRIC EVIDENCE

Similar to fingerprint ridges, ear prints provide stable biometric information by capturing the distinctive morphology of the auricle, including the tragus imprint, antihelix, and helix curvature. Projects such as FearID (n=1229) and research by Curiel López de Arcautea and Alberink & Ruifrok confirmed the discriminative capability of ear prints, which were initially used as forensic evidence in 1965 (Hirschi) [3]. In ear print-to-ear photo matching, recent morphometric investigations (e.g., Habal et al., 2021) confirmed a 98.6% concordance for antihelix curvature [3]. When fingerprints are inconclusive or unavailable, this technique shows potential.

1.3 CHALLENGES IN EAR PRINT VISUALIZATION USING CONVENTIONAL METHODS

A number of obstacles restrict the usefulness and admissibility of ear prints as biometric evidence in forensic investigations. These difficulties are listed as follows:

1.3.1. INCONSISTENT DEPOSITION DUE TO VARIABLE PRESSURE AND CONTACT SURFACE

The pressure used and the surface curvature during contact have a significant impact on ear prints. Ear prints include more expansive and less distinct anatomical features like the helix and tragus, in contrast to fingerprints, which are made up of tiny ridge patterns. These leave incomplete, smeared, or distorted impressions since they don't always transfer to surfaces, especially when pressure and placement are changed. [4]

1.3.2 SURFACE TOPOGRAPHY AND TEXTURE INTERFERENCE

The quality of the visualization is greatly influenced by the kind and texture of the surface the ear print is placed. Porous or uneven surfaces break the print's continuity and decrease the effectiveness of powder adhesion, whereas smooth, nonporous surfaces like glass may allow for better print development. [5]

1.3.3. LACK OF STANDARDIZED COLLECTION PROCEDURES

As of right now, there is no standard procedure for gathering ear prints. Reproducing the same print from the same person is challenging due to variations caused by changes in the angle of contact, ear orientation, movement during contact, and ambient influences.[6]

1.3.4. VARIABILITY DUE TO PHYSIOLOGICAL AND ENVIRONMENTAL FACTORS

Visibility is affected by moisture content, skin oil secretion, and the amount of time between the print's deposition and development. These environmental and physiological variations lead to intra-individual variability, which compromises the technique's dependability. [4]

1.3.5. INEFFECTIVENESS OF CONVENTIONAL POWDERS

The majority of powders that are sold commercially are designed to fit the ridges of fingerprints and do not work well on the wider, less greasy ear leftovers. Such powders give poor contrast and clarity on curved or textured surfaces, making it especially challenging to visualize ear prints. [7]

1.3.6. SCIENTIFIC AND LEGAL SKEPTICISM

Ear prints are still viewed with suspicion in the fields of forensic science and law, despite advances in technology. Their forensic admissibility is restricted by the absence of generally recognized biometric standards and subjective interpretation techniques. Although research like FearID has confirmed their individuality, wider acceptance is still difficult. [8]

1.4 ENVIRONMENTAL AND HEALTH CONCERNS OF COMMERCIAL CHEMICAL POWDERS

Commercial fingerprint powders are widely used in forensic investigations; however, because of their composition and particle properties, there are serious health and environmental problems. The following are core issues:

1.4.1. HEAVY METAL CONTAMINATION

Commercial powders used in fingerprint detection have been found to include concerning amounts of metallic components, including aluminium, iron, zinc, magnesium, manganese, nickel, and, in certain situations, up to 41% lead. Over time, secondary contamination from empowered clothing or transport vehicles may provide chronic concerns, even if occupational exposure limits may not always be surpassed during normal use [9]

1.4.2. NANOPARTICLE-RELATED RESPIRATORY HAZARDS

Emerging research highlights growing concerns about commercial nanoscale powders for forensic applications, such as silica, titanium dioxide (TiO_2), gold, and other metallic variants. Deep penetration of respiratory passageways by nanoparticles with diameters of 0.2–2 μm enables them to reach alveolar regions, where traditional clearance mechanisms are less efficient [10]. For example, in mouse models, inhaled TiO_2 nanoparticles have been associated with pulmonary inflammation, fibrosis, and even systemic translocation to organs like the liver and brain [11]. After two weeks, rats exposed to TiO_2 aerosols showed signs of pulmonary inflammation and nasal tissue damage [12]. Furthermore, chronic respiratory disorders have been linked to prolonged exposure to amorphous silica nanoparticles, which have been demonstrated to trigger mast-cell-dominated inflammatory responses in lung tissue. Silicosis, which is characterised by alveolar macrophage activation and progressive fibrosis, is linked to chronic inhalation of silica dust [13]. When taken as a whole, these results highlight serious worries regarding the hazards to environmental and occupational health posed by powders based on nanoparticles, highlighting the pressing need for non-toxic, biodegradable substitutes like the suggested Biogenic Black Powder.

1.5 RATIONALE FOR AN ECO-FRIENDLY AND SUSTAINABLE FORENSIC ALTERNATIVE

Agro-waste-derived products, especially activated charcoal made from coconut shells, are being investigated as viable substitutes for traditional commercial powders due to the growing need for ecologically friendly forensics. With their advantageous physicochemical characteristics, such as low heavy-metal concentration (sulfur ~ low; nitrogen negligible levels) and high fixed carbon (~21.8%) with little ash (~1.8%), coconut shells are abundant and rich in carbon, making them perfect precursors for the manufacture of activated carbon [14]. High porosity and robust oleophilicity, two essential qualities for successful latent print visualization, are facilitated by these attributes. Saengkaewsuk and Seelanan (2024) used burnt coconut husk to create a carbon powder (~20 µm), which they showed could effectively identify latent fingerprints on semiporous and nonporous surfaces. Up to 60 minutiae points, equivalent to imported commercial powders, were found to be a statistically non-significant difference at the 0.05 level when examined utilizing a Mini AFIS system. The preparation was found to be easy, inexpensive, and safe for the environment [3]. Hameed, Mohammed, and Zageer's complementary study from 2022 contrasted activated carbon made from Alhagi biomass with charcoal that is sold commercially. According to the study, activated carbon formulations performed better in print clarity than commercial charcoal and held their efficacy for up to 15 days on a variety of nonporous surfaces [15]. Additionally, activated carbon with a particularly high specific surface area (e.g., 516 m^2/g with NaOH activation) is produced by steam or chemical activation at about 900 °C, allowing for higher adsorption of oily wastes [14]. Research on mesoporous coconut shell materials supports adhesion stability by confirming intrinsic macroporosity and nanopore frameworks [16]. The combined results of these studies demonstrate that activated carbon generated from coconut shells satisfies critical requirements for a latent print powder that is safe, biodegradable, and extremely effective. A good contender for creating the suggested Biogenic Black Powder to visualize ear prints in real-world settings, it stays away from dangerous chemicals and synthetics, adheres to green forensic principles, and provides inexpensive, field-friendly preparation techniques.

II. REVIEW OF LITERATURE

2.1. JUNOD, MEUWLY, & MARGOT (2012): EARPRINTS AS FORENSIC EVIDENCE: A REVIEW

A thorough examination of ear prints' present status in forensic science is given by Junod et al. (2012). Major issues are highlighted in the review, including uneven deposition brought on by different pressures and involuntary head movement during contact, which frequently results in partial or hazy prints. The absence of defined methods for collection is also criticized in their study, which points out that a variety of factors, including ear placement, surface type (glass vs. textured), and time since deposition, have a substantial impact on print quality. Additionally, Junod and associates stress that traditional fingerprint powders frequently produce poor contrast on curved or uneven surfaces since they are not designed for broad, greasy ear remains. The analysis points out that although the FearID experiment showed discriminating patterns in a controlled environment, commercial powders are unable to reliably reproduce similar outcomes in actual settings. By promoting the creation of surface-adaptive, residue-specific visualization agents, Junod et al. provide theoretical justification for the adoption of activated charcoal as a more appropriate substitute for ear print detection. [17]

2. 2. MEIJERMAN, SHOLL, & VAN DER LUGT (2006): EXPLORATORY STUDY ON CLASSIFICATION AND INDIVIDUALISATION OF EARPRINTS

Early empirical research on ear prints is presented by Meijerman et al. (2006), who concentrate on the limitations and classification potential of these prints for individual identification. Although they are susceptible to contact dynamics, they found that small anatomical factors such as Darwin's tubercle, helix contour, and tragus–antitragus angles can provide consistent class characteristics. Repeated experiments on surfaces, including glass and plastic, revealed that contact force and time delay before dusting were two elements that affected print variability across persons over several trials. According to their observations, conventional powders have trouble capturing fine morphological characteristics, especially in extremely oily, non-pore-rich residuals. They postulate that for forensic accuracy, powders with greater oleophilicity and mesh-adapted performance are required. Meijerman et al.'s investigation highlights the potential forensic advantages of fine-particle carbon-based powders, including activated charcoal, which stick more uniformly to oiled residues and curved ear contact points, despite their concentration on fingerprint powders. [5]

2.3. SAENGKAEWSUK & SEELANAN (2024): DEVELOPMENT OF CARBON POWDER FROM BURNT COCONUT HUSK FOR LATENT FINGERPRINT DETECTION

Saengkaewsuk & Seelanan (2024) highlight the forensic potential of carbon powders obtained from agro-waste, highlighting their applicability to ear print visualization, even though this study concentrates on fingerprints. The ~20 µm carbon powder, derived from burnt coconut husk, matched commercial powders in developing latent prints across both non-porous and semi-porous surfaces. Tests against a Mini-AFIS system yielded up to 60 matchable minutiae, statistically indistinguishable from commercial benchmarks. The study reveals that nature-derived carbon can produce high contrast and adherence to oily residues and substrates like glass and plastic, characteristics critical for ear print enhancement. The preparation method is straightforward and eco-friendly, involving only carbonization and grinding. According to Saengkaewsuk and Seelanan, these carbon powders offer forensic investigation a more secure and environmentally friendly option. Although the residual complexity varies among ear prints, these findings imply that comparable coconut-based charcoal might work just as well when modified for the wider contact and curvature unique to ear prints.[3]

2.4. HAMEED, MOHAMMED, & ZAGEER (2022): BIOGENIC ACTIVATED CARBON VS. COMMERCIAL CHARCOAL FOR LATENT PRINT DETECTION

A study by Hameed et al. (2022) compared the effects of commercially available charcoal powders and activated carbon made from the Alhagi plant on the establishment of latent fingerprints on nonporous surfaces. Despite being fingerprint-focused, the study offers important new information for ear print technology. The activation procedure was optimized by the authors employing a central composite design with KOH impregnation at 630°C, a 1:2.6 ratio, and an activation time of 160 minutes. We tested the resulting biogenic powder (~20 µm) on ceramic, glass, aluminum, and plastic surfaces. Clear prints were visible for up to 15 days, outperforming conventional charcoal, which faded after a week. The results showed greater ridge clarity and retention.The powder's capacity to stick to oily residues and provide sharp contrast was validated by high-resolution imaging, indicating that it might work well for the larger, oilier deposits found in ear prints. Given the identical residue properties and surface interactions, the study's statistical rigor ($p < 0.05$) and multi-surface testing make it extremely relevant for your ear print enhancement research. [15]

2.5. SAENGKAEWSUK & SEELANAN (2024): COCONUT HUSK CARBON POWDER FOR LATENT PRINT DETECTION

An environmentally friendly technique for creating coconut husk carbon powder (~20 µm) was investigated by Saengkaewsuk and Seelanan (2024), who also evaluated its suitability for latent fingerprint detection. The authors produced a charcoal powder by simple burning and grinding, which was tested on semiporous and nonporous (glass, plastic) surfaces. The final prints performed similarly to imported commercial powders (Mini-AFIS), achieving up to 60 distinguishable minutiae points. The powder's granular roughness was ideal for sebum absorption, and it showed outstanding contrast, adherence, and reduced background staining. Crucially, no dangerous chemicals were used in its manufacture, thus minimizing the exposure to toxins and the impact on the environment. The authors come to the conclusion that carbon powder made from coconuts provides a safe, effective, and sustainable forensic substance. [16]

2.6. ROY, KUMAR, & MIA (2023): DEVELOPMENT OF LATENT FINGERPRINT USING CARBON POWDER

A handmade carbon-based powder for latent fingerprint development was studied by Roy, Kumar, and Mia (2023). Their process involved gathering leftover charcoal or soot from candle flames, crushing it into a fine powder, and then dusting it on a variety of porous and nonporous surfaces. They confirmed distinct ridge and pore detail across glass, metal, and coated wood by validating ridge quality using both automatic matching and manual examination. According to the study, producing powder from candle or charcoal sources was affordable, non-toxic, and easily applied in environments with limited resources. Notably, in situations where commercial powders were either unavailable or delayed, the carbon powder consistently achieved results. This DIY carbon-based powder's appropriateness for environmentally responsible ear print visualization is further supported by its proven efficacy on a variety of surfaces, which highlights its versatility for large-area prints like ear impressions. [18]

2.7 KUMAR ET AL. (2023): MESOPOROUS COCONUT SHELL CHARS – STRUCTURAL INSIGHTS

A thorough physicochemical analysis of charcoals generated from coconut shells was carried out by Kumar et al. (2023) to improve them for adsorptive uses. By using methods including scanning electron microscopy (SEM), Brunauer-Emmett-Teller (BET) surface area measurement, and X-ray diffraction (XRD), the scientists showed that when carbonized chars were activated with KOH, they produced specific surface areas of up to ~1,500 m^2/g. This high porosity and mesoporous structure enables enhanced oleophilic interaction with sebum-based residues, critical for latent print visualization. A well-developed microstructure with a uniform pore size distribution (~2–50 nm) was seen in SEM images, indicating a high potential for powder adhesion over large regions, such as ear contacts. The study's structural features meet the specifications for fine-particle, high-contrast visualization powders, despite the fact that forensic performance was not directly tested. Additionally, they found that inert atmosphere carbonization increased the lifespan of powder by producing chars with reduced ash concentration and graphitized layers. According to the scientists, adjusting activation parameters (such as temperature and KOH ratio) might fine-tune particle size and porosity, allowing for adaptation for various residue kinds, including thicker oil-layered ear prints. The data suggests that a mesoporous coconut-charcoal powder that combines good adhesion, clarity, and environmental sustainability could be developed specifically for ear-print detection. [16]

2.8 PELCLOVA ET AL. (2011): OCCUPATIONAL RESPIRATORY RISKS OF ULTRAFINE TiO_2

The respiratory health of employees exposed to ultrafine titanium dioxide (TiO_2), a component of several fluorescent forensic powders, was investigated by Pelclova et al. (2011). Pulmonary function tests revealed a spirometric decline suggestive of early obstructive or restrictive patterns, and the inquiry evaluated oxidative stress markers (e.g., 8-isoprostane, IL-8) in sputum and bronchoalveolar lavage. Ground-glass opacities, an indication of oxidative damage, were seen on CT scans in the peripheral lung regions. According to the study, nanopowders can enter the lungs deeply and cause tissue damage, inflammation, and the recruitment of immune cells. Given the same hazards associated with frequent exposure to bright or colored powders, these findings are extremely pertinent to forensic practitioners. According to Pelclova et al., there is a need for safer, natural powders that provide a biocompatible substitute for nanoparticles, like formulations based on coconut charcoal. [19]

2.9 NAKAZATO ET AL. (2013): REPEATED INHALATION TOXICITY OF TiO_2 NANOPARTICLES IN RATS

In a subacute inhalation study, rats were exposed to aerosolized TiO_2 nanoparticles for two weeks by Nakazato et al. (2013). Epithelial degeneration, inflammatory infiltration, and oxidative stress characterized by elevated ROS and glutathione depletion, were observed in the nasal and pulmonary tissues. The deposition of nanoparticles in the lung interstitium and alveolar macrophages was verified by electron microscopy. In order to maintain forensic efficacy without sacrificing occupational safety, it is crucial to develop non-nano particulate powders, such as activated coconut charcoal, that present little to no inhalation hazards. The study demonstrated the biological activity of nano-sized forensic powders. [20]

2.10 BUZEA, PACHECO, & ROBBIE (2007): NANOPARTICLE SOURCES AND TOXICITY
In their comprehensive study of nanoparticle toxicity, Buzea et al. (2007) focused on metal oxide, silica, and TiO_2 particles that are frequently found in industrial or forensic powders. They present proof that particles with sizes between 0.2 and 2 µm can enter the pulmonary system profoundly and make their way to the alveoli, where they avoid removal and cause oxidative stress, chronic inflammation, and systemic organ absorption. Because nano-enabled modifications meant to boost contrast may unintentionally entail long-term health and environmental hazards, these findings are particularly pertinent to the use of forensic powder. The authors emphasize the significance of sustainable material science in forensic innovation by promoting non-nanoparticle, biodegradable substitutes like activated carbon. [21]

III. AIM AND OBJECTIVES

3.1. AIM
To develop an eco-friendly, sustainable powder from coconut shell charcoal for the effective visualization of latent ear prints on various surfaces.

3.2. OBJECTIVES
1. To use a regulated open-fire carbonization process to turn coconut shells into finely powdered charcoal.
2. To guarantee the economical and ecologically safe creation of ear print visualization materials.
3. To evaluate the biogenic black powder's suitability for use on nonporous materials such as plastic, metal, and glass.
4. To assess the ear prints created with the produced powder in terms of visibility, clarity, and contrast.

IV. MATERIALS AND METHODS

4.1 MATERIALS USED
4.1.1 PRIMARY MATERIALS
- Coconut shells (as the carbon source)
- Open flame or gas stove
- Metal plate or brick base (for burning)
- Lid or vessel (to cut off air supply)
- Grinder or mortar and pestle
- Fine mesh sieve

Figure 1 CHARCOAL

Figure 2 FINE CHARCOAL POWDER

4.1.2 FOR APPLICATION
- Clean glass, metal, and plastic surfaces
- Soft brush (camel hair brush or cosmetic brush)
- White light source or oblique light
- Camera/ Phone (for documentation)

4.2 PREPARATION OF BIOGENIC CHARCOAL
4.2.1 CLEANING AND DRYING OF COCONUT SHELLS
We manually cleaned the coconut shells, eliminating any fibers or hair-like debris. The shells were properly cleaned with water and left to dry in the sun for a few hours to eliminate any remaining surface moisture.

4.2.2 CARBONIZATION PROCESS

A brick or metal platform was used to burn the dried coconut shells over an open flame. To prevent total combustion into ash, the burning was carefully supervised. They were promptly covered with a lid or metal sheet to cut off the oxygen supply, allowing the shells to cool and settle into charcoal form after they went black and achieved that stage (without flaming red or disintegrating into powdery ash).

4.2.3 GRINDING AND SIEVING THE CHARCOAL INTO FINE POWDER

A stone grinder or mixer was used to grind the cooled charcoal into a fine powder. To guarantee smooth consistency and uniform particle size appropriate for forensic powder application, the powder was run through a fine mesh filter (less than 75 µm). For use and storage, the resultant powder was gathered in airtight containers.

4.3. APPLICATION METHODOLOGY

Accuracy and reproducibility were ensured by applying the biogenic black powder for ear print visualization in a controlled setting. To remove any existing pollutants, the glass panels, plastic sheets, and metal plates were first cleaned and smoothed. Volunteers were instructed to gently press their ear against the surface, using their body weight without exerting any extra force, to leave latent ear prints. This made it possible for the ear's natural secretions, such as sweat and oil, to spread out and create a latent ear impression. To prevent smearing or over-powdering, the charcoal powder created from partially burned coconut shells was dusted over the latent region with a soft brush, ideally a camel-hair brush. To enable the fine powder particles to stick specifically to the greasy residues in the ear print, the brush was softly moved over the area in tiny circular motions. To increase contrast and visibility, extra powder was carefully tapped off, and any remaining loose particles were gently brushed or blown away. After that, the improved ear prints were examined in both direct and indirect light to evaluate their definition, clarity, and visibility of ridges or contours.

High-resolution photos with constant lighting and angle were captured with a digital camera or a cell phone camera for documentation. To assess the efficacy of the biogenic charcoal-based formulation, the visual quality of the formed ear prints was captured and contrasted with those achieved using commercially available fingerprint powders.

V. DATA ANALYSIS AND INTERPRETATION

The ear print that was created using the powdered biogenic charcoal made from coconut shells was closely inspected for clarity, anatomical definition, and suitability for forensic use. A clear visualization of morphological features such as the helix, antihelix, tragus, and lobule was produced by the powder's strong adherence to the sweat and sebum residues found in the latent ear impression, according to the investigation. With little smudging or overdevelopment, the ear print displayed a sufficient contrast to the background, suggesting that the powder is appropriate for curved and nonporous surfaces like glass.

The powder's small granularity allowed it to blend into delicate skin ridges, increasing the amount of detail that could be photographed. Notably, earlobe piercings and other characteristics were visible in some impressions, which may help identify female people. The coconut charcoal performed competitively without posing health risks when compared to commercial powders. All things considered, the findings point to the created powder's effectiveness and dependability for forensic ear print visualization, particularly in controlled settings.

FIGURE 3 DEVELOPED EAR PRINT USING COCONUT SHELL CHARCOAL POWDER ON GLASS SURFACE

VI. RESULT AND DISCUSSION

The study effectively showed that the powdered biogenic charcoal made from leftover coconut shells is quite good at bringing out latent ear prints, especially on smooth, nonporous surfaces like glass. Anatomical elements that are essential for biometric identification, such as the lobule borders, tragus and antitragus, and helix and antihelix curves, were visible in the generated prints.

The presence of earlobe piercings in some prints, particularly those of female patients, was a significant finding, indicating that these characteristics may serve as further markers for gender distinction in forensic settings. In addition to offering great contrast and clarity without overdevelopment or excessive background staining, the powder demonstrated exceptional adherence to the greasy and sweaty residues normally left by the ear.

Furthermore, the prints held up well under gentle handling, suggesting that the produced powder allows realistic forensic procedures without sacrificing the quality of the evidence. By avoiding the use of hazardous materials like titanium dioxide (TiO_2), which are frequently found in commercial powders and provide breathing concerns, the powder's environmentally friendly and sustainable preparation process is in line with green forensic principles. This natural substitute not only worked just as well as traditional powders, but it was also less expensive and non-toxic. Since such substrates are commonly seen in real-world crime scene applications, their efficacy on smooth, clean surfaces further increases its usefulness. All of these results support the powder's potential as a practical and eco-friendly alternative for forensic ear print examination.

VII. ADVANTAGES AND DISADVANTAGES

7.1. ADVANTAGES

- The powder is manufactured from coconut shell trash, supporting eco-friendly and sustainable forensic practices.
- It is safe for users and lowers hazards to occupational health because it is devoid of dangerous compounds and nanoparticles.
- Simple and inexpensive, the preparation method is perfect for field research or laboratories with limited resources.
- Better print vision is made possible by the powder's strong adhesion to the ear's natural sweat and oil secretions.
- On nonporous surfaces, it ensures that anatomical characteristics like the lobule, tragus, and helix are visible by providing exceptional contrast.
- Earlobe piercings are easily noticeable and can help with gender-based identification, particularly in females.
- It is appropriate for preliminary investigations or on-site forensic work because it requires little equipment and knowledge.

7.2. DISADVANTAGES

- Sweat or oil content varies from person to person and affects the quality of the generated print.
- Clarity and interpretation may be impacted by ear print damage or smudging caused by excessive brushing or inappropriate handling.
- The powder works best on nonporous, smooth surfaces; it might not work as well on textured, porous, or dusty materials.
- Reproducibility may be impacted by incomplete or distorted prints caused by variations in pressure and angle during ear contact.
- As of right now, there are no set norms or regulated methods for gathering and examining ear prints made with natural powders.

VIII. FUTURE DIRECTIONS

- Provide scientifically proven techniques for collecting and improving ear prints with biogenic powders.
- To increase the powder's forensic applicability, test its efficacy on a larger variety of surfaces, such as wood, painted walls, and cloth.
- To increase the accuracy of identification in forensic databases, connect improved ear prints with biometric recognition software.
- Refine the particle size or mix the powder with natural, non-toxic binders to increase adherence and picture clarity.

- To evaluate practical effectiveness, do comparative experiments using commercial powders under real-world case-like settings.
- Examine how factors like age, skin type, and surroundings affect the stability and visibility of ear prints.
- Make portable forensic kits with this natural powder so that police personnel can use them at crime scenes.

IX. CONCLUSION

The study demonstrates that a sustainable and environmentally friendly substitute for commercial powders used to produce latent ear impressions is biogenic charcoal powder made from leftover coconut shells. The helix, tragus, and antihelix are among the important ear components that are successfully highlighted, and they also offer other identification indicators, such as ear piercings. It is a great tool for forensic applications, particularly on nonporous surfaces, because to its non-toxic composition, ease of preparation, and good adherence to skin secretions. The benefits of sustainability, affordability, and safety greatly encourage its use in forensic practice, notwithstanding certain drawbacks concerning surface compatibility and deposition variability. This method has the potential to become more widely used in forensic labs and crime scene investigations with additional development and standardization.

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